Marine Sensor/Autonomous Underwater Vehicle Integration Project

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LONG-TERM GOALS

The long-term goal is continued support of research that will integrate a number of advanced oceanographic sensors into autonomous underwater vehicles. Support of individual sensor projects at USF takes the form of: 1) enhancements to existing facilities; 2) sensor/vehicle integration; 3) calibration expenses to keep equipment at the necessary standards and ensure integrity of resultant data; 4) support of AUV operations; 5) experimentation and testing of methodologies and equipment and; 6) engineering/consultation.

OBJECTIVES

This project provides the necessary resources for the Center for Ocean Technology (COT) to support the technical requirements of USF Marine Science's AUV related sensor projects. The objective is to efficiently design, integrate, test and deploy developed sensors on AUVs. This work is accomplished through use of the Center's varied labs, equipment and human resources.

APPROACH

COT provides comprehensive resources for AUV/sensor integration, testing and deployment. The approach is to provide the faculty and students associated with the sensor development projects with an experienced, suitably trained staff and appropriate equipment resources to effect this mission.

WORK COMPLETED

AUV Sensor Integration

The COT-engineered pH sensor for studying the ocean carbon cycle (Byrne, "Development of an Underwater *In Situ* Spectrophotometric Sensor for Seawater pH") was adapted and deployed on the British (Southampton Oceanographic Centre [SOC]) "Autosub" AUV for two deployments during the past year. One in December of 1997 off the east coast of Florida and the second at the Bermuda Biological Research Station at Bermuda. Both deployments involved significant modification of LON Works interfacing to accommodate upgrades in the British design. The sensor functioned well during both deployments and provided valuable research data.

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The dual light sheet (DLS, Hopkins, "Comprehensive Marine Particle Analysis System") was adapted to the FAU OEX AUV in early September, 1997. Further modification and improvement of the OEX payload was completed including new syntactic foam, integration of a backup data logging system and experimental MEMS accelerometers to monitor payload motion. The DLS was deployed at the ONR sponsored CoBOP operation at Lee Stocking Island, Bahamas, in late May 1998. COT supported operations including: 1) deployment from the RV Suncoaster; 2) chase boat supplied and operated; 3) retrieve and analyze data for researchers and; 4) provide dive support. The deployment was very successful allowing the first ever field test of an AUV mounted nonintrusive particle measurement system.

The real-time ocean bottom topography system (ROBOT, Carder, Costello "Optical Variability and Bottom Classification in Turbid Waters") was integrated, tested and deployed under this project in early 1998. This project's support included: 1) fabrication of OEX payload shell and mechanical structure; 2) design and fabrication of a precision adjustable mounting system for the ROBOT sensor; 3) syntactic foam; 4) drop weight system; 5) testing including trim and balance; 6) deployment at CoBOP; 7) data retrieval and analysis for researchers and; 8) chase boat and dive support for field operations. Deployments were successful providing images of stromatolite structures retrieved from overflights of the test area.

Progress is being made on preparations to deploy the ROBOT OEX payload at the FAU South Florida Test Facility in early December 1998. This project is supporting: 1) pre-mission testing; 2) travel and transport to the deployment site and; 3) dive and operations support.

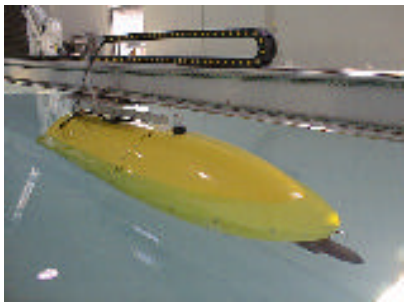
AUV operations training was completed for the FAU OVII and OEX vehicles under this project. FAU officially transferred the OVII vehicle to USF for operations using optical sensor payloads.

The spectrophotometric elemental analysis system (SEAS, Byrne, "Autonomous In-Situ Analysis Of The Upper Ocean: Construction Of A Compact, Long Pathlength Absorbance Spectrometer") was integrated into an OEX payload and deployed at CoBOP in late May 1998. The integration included: 1) fabrication of custom mounting; 2) design of simple AUV sample port system and; 3) syntactic foam. This integration was accomplished efficiently as the approach was to make necessary modifications to the designed ROBOT payload to accommodate the new sensor. Deployment was successful and provided the first AUV field test of the SEAS instrument.

Work is continuing on AUV integration of a nutrient sensor (Fanning, "Development of a Remote Sensing Capability for Nitrogen-Bearing Nutrients on an Unmanned Underwater Vehicle in the Coastal Ocean.") Deployment on an AUV is pending sensor completion.

AUV operations locally (and remotely in conjunction with FAU) will continue to be supported through the end of the project.

(a)



(b)

Figure 1 (a) Deployment of the DLS instrument at CoBOP, May 1998, (b) interior of 9,000 gallon test flume showing ROBOT in an OEX test vehicle.

Sensor/System Test Flume

The Center for Ocean Technology is home to a 9,000 gallon test flume for pre-testing developed sensors before expensive deployment, figure 1(b). Significant upgrades to the flume's internal structure were completed over the past year. These include: 1) corrosion proofing internal water turning vanes; 2) improved water filtration system; 3) improved water drainage system; 4) addition of a seawater fill system to accommodate high density testing and; 5) an improved water recirculating system.

Support Equipment

The Center for Ocean Technology provides limited calibration and maintenance capability for the Department. Miscellaneous lab equipment to support development efforts has been purchased; however, this equipment is also used to support maintenance of completed sensor systems as well as AUVs.

Training

Training of support personnel was completed including: LONWorks, ProEngineer Advanced Course, PittCon Technology Conference short courses, American Vacuum Society short courses. Several conferences were attended including MTS IEEE Oceans 98 and Oceanology International 98.

Experimentation and Testing

A rapid and inexpensive system for experimentation and testing of instrument payload sections has been designed and is under construction/upgrading at this writing. The unit consists of an OEX tail section configured to accept standard OEX payloads. The unit is being fitted with remote control capabilities. Originally designed to operate in the COT test flume, plans are to provide for minimal operations at sea to allow real time monitoring of sensor packages.

RESULTS

AUV Sensor and Deployments

pH sensor: several successful operational tests of both the vehicle and sensor. Gained experience with British SOC Autosub vehicle. * Dual Light Sheet: adapted to the FAU OEX AUV in early September, 1997, improved configuration in early 1998. DLS deployed at CoBOP in May 1998 and provided first successful field test of the non-intrusive particle velocity measurement system. *Nutrient Sensor: continued work to ready the unit for field deployment. *AUV operations: Florida west coast, Florida east coast, Lee Stocking Island. * The Center's 9,000 gallon test flume has been upgraded and can now provide testing of AUV sensors with sea water.

IMPACT/APPLICATIONS

The Center for Ocean Technology continues to build significant expertise in: 1) adapting sensors to AUVs; 2) operating AUVs at sea; 3) building AUV specific custom hardware, and; 4) testing AUVs and related systems. This work covers several aspects of AUV integration including LONWorks, adaptive sampling, remote control and monitoring, sea sampling, etc. This expertise is available not only for USF- AUV related project but to the general oceanographic research community as well.

TRANSITIONS

The continued AUV related interactions between USF COT and FAU strengthen arguments for AUV use as a viable oceanographic research tool. The ongoing efforts of this project will help to increase the efficiency of marine research and will aid in transitioning the general technology to other research organizations.

RELATED PROJECTS

1) Byrne, Robert. "Development of an Underwater *In Situ* Spectrophotometric Sensor for Seawater pH."
2) Byrne, Robert. "Autonomous In-Situ Analysis Of The Upper Ocean: Construction Of A Compact, Long Pathlength Absorbance Spectrometer"
3) Carder, Kendall and Costello, David. "Optical Variability and Bottom Classification in Turbid Waters."
4) Fanning, Kent. "Development of a Remote Sensing Capability for Nitrogen-Bearing Nutrients on an Unmanned Underwater Vehicle in the Coastal Ocean."
5) Hine, Al. "Sea Floor Acoustic Properties, Test Bed Definition, Geologic Mapping and Sedimentary Processes Using Autonomous Underwater Vehicle (AUV) Technology."
6) Hopkins, Thomas. "Comprehensive Marine Particle Analysis System."